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ABSTRACT

Project Special Elementary Education for the Disadvantaged (SEED) is a national program in which professional mathematicians and scientists from universities and industry teach abstract, conceptually oriented mathematics to full-sized classes of elementary school children as a supplement to their regular mathematics instruction. In the Dallas (Texas) public schools the Socratic group-discovery approach of Project SEED was used with all grade levels in elementary schools with high percentages of minority and low-income students. The 1990-91 evaluation considered the impact of Project SEED on students in the Dallas Learning Centers program as well as on those not in the Learning Centers. Achievement test results of more than 1,300 students in grades 4 through 6 were compared with those of non-SEED students. An immediate impact could be measured after one semester of SEED instruction, and there was a cumulative impact of more than one semester. Retention of mathematics skills was apparent as long as 4 years after SEED instruction, and Project SEED students were more likely to enroll in advanced mathematics in secondary school. Twelve tables and five figures present evaluation findings. (Contains 4 references.) (SLD)

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EVALUATION OF

PROJECT SEED
1990-91

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DEPARTMENT OF EVALUATION AND PLANNING SERVICES

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THE EVALUATION OF PROJECT SEED 1990-91

EPS91-043-2

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Approved Report of the Department of
Evaluation and Planning Services

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Dallas, Texas
January 1992

EXECUTIVE SUMMARY

EVALUATION OF PROJECT SEED
1990-91

Evaluators: William J. Webster and Russell A. Chadbourn

Project SEED is a nationwide program in which professional mathematicians and scientists from major universities and research corporations teach abstract, conceptually oriented mathematics to full-sized classes of elementary school children on a daily basis as an extra-period supplement to their regular arithmetic program. The mathematics is presented through the use of a Socratic group discovery format in which children discover mathematical concepts by answering a sequence of questions posed by the SEED instructor. Project SEED believes that only persons who understand mathematics in depth possess the versatility to capitalize on the unconventional and often original insights that children are capable of making in an open-ended mathematical dialogue. The initial mathematical topics are chosen from high school and college algebra to reinforce and improve the students' critical thinking and computational skills and to help equip them for success in college-preparatory mathematics courses at the secondary level. Subsequent material establishes the mathematical foundation for a number of advanced areas of study and progresses into advanced topics in abstract algebra and other areas. Project SEED teaches entire regular elementary school classes rather than specially selected groups of students. Although SEED was originally begun as a program for the educationally disadvantaged (the acronym SEED stands for Special Elementary Education for the Disadvantaged), the project now is implemented with all level of children across the nation. In its Dallas Independent School District (DISD) implementation, SEED was used with all levels of students and was not intended as a program for a specific group of students. The DISD implementation of SEED also continued SEED's nationwide practice of using intact classes in the schools in which it is implemented.

PREVIOUS STUDIES

There have been four previously implemented series of studies on the impact of SEED instruction at the 4-6 grade levels (Mendro, 1983; Webster and Chadbourn, 1988, 1989, 1990). These studies on SEED took an indepth look at the impact of SEED instruction on mathematics achievement as measured by the *Iowa Tests of Basic Skills (ITBS)* and a locally developed curriculum-referenced test, the *Survey Tests of Essential Elemants/Learner Standards* (*STEELS)* and on student attitudes toward mathematics as measured by the enrollment of students in advanced math courses.Most of the students in the SEED group were also Learning Center students, thus introducing an intervening variable into the process of interpreting the results. Analyses of Learning Center Reading achievement was conducted to provide some measure of the impact of the Centers independent of SEED. Early non-Center SEED groups were also studied for this purpose.

Although the primary focus of this series of investigations was to examine the impact of Project SEED in the Learning Center environment, part of the study focused on non-Learning Center students who had only one semester of SEED in the fourth, fifth, or sixth grade. The achievement impact of only one semester of SEED instruction was immediate and still present after two years and former SEED students enrolled in more higher level math classes than did their matched comparison groups.

The results of these studies in the Learning Centers suggested that SEED instruction in the Learning Centers contributed substantially to increased mathematics achievement as measured by the *ITBS* and *STEELS*, increased enrollment in higher level mathematics courses, a cumulative impact on mathematics achievement (longer exposure to SEED appeared to accelerate measured mathematics achievement growth), and retention of mathematics gains for at least two years after exposure to SEED.

EVALUATION QUESTIONS

The major purpose of this series of studies is to determine if the findings from the previous studies can be replicated. Major evaluation questions include:

1.0 What is the impact of one, two, and three semesters of SEED instruction at the 4-6 level on mathematics achievement as measured by the *ITBS*?

2.0 Is there a cumulative impact of SEED instruction on mathematics achievement?

3.0 Do former SEED students enroll in more higher level math classes than their non-SEED comparison groups.

4.0 What is the long-term impact of three of SEED instruction on mathematics achievement?

All SEED and comparison groups were matched on pretreatment variables. The variables were sex, ethnicity, socioeconomic status, grade level, and achievement level on the Mathematics Total subtest of the *ITBS*. All studies were conducted at the 4-6 grade level. Seven different samples were used:

1.0 Students who had one semester of SEED in the South Dallas Learning Centers in the fourth grade in 1990-91; two semesters of SEED in the South Dallas Learning Centers in the fourth and fifth grade in 1989-90 and 1990-91; or, three semesters of SEED in the South Dallas Learning Centers in the fourth, fifth, and sixth grades in 1988-89, 1989-90, and 1990-91. These students and their matched comparison groups were compared on achievement on the *ITBS*. (Study A). Further cross-replication was accomplished by also using three samples of students from the West Dallas Learning Centers.

2.0 Students who had three semesters of SEED in the South Dallas Learning Centers in grades 4-6 in 1984-87, 1985-88, 1986-89, or 1987-90. These students and their matched comparison groups were compared on achievement on the *ITBS* both for the years that they were exposed to SEED and up to four years later. Course enrollment was also compared for these students (Study B).

MAJOR EVALUATION FINDINGS

Major evaluation findings can be summarized in four statements:

1.0 There is an immediate impact of one semester of SEED instruction on mathematics achievement as measured by the *ITBS*. This impact ranged as high as 1.48 years but generally was in the area of three to four months.

2.0 There is a cumulative impact of more than one semester of SEED instruction on mathematics achievement as measured by the *ITBS*. That is, the more semesters of SEED instruction that children are exposed to (up to three), the greater the difference in mathematics achievement between SEED students and their matched comparisons. Table 1 displays the immediate and cumulative impact of SEED instruction on mathematical Concepts(C), Problem Solving (PS), Computation (C), and Math Total (T). The metric is grade equivalent differences between the various SEED groups and their matched comparisons after one, two, and three years of instruction. No difference would be a "0".

3.0 Retention of mathematics skills by former SEED students is still present four years after SEED instruction. That is, four years after completing their last of three semesters of SEED (one semester each in the fourth, fifth, and sixth grades), former SEED students now in the tenth grade still significantly outperform their matched comparisons in mathematics as measured by the *Tests of Achievement and Proficiency* (*TAP*). Table 2 shows the results for a group of 1984-1987 SEED and comparison students four years after exposure to SEED. Differences are still statistically significant, being about five months.

4.0 Former SEED students enroll in significantly more higher level mathematics courses than do their matched comparisons. That is, in middle and high school, former SEED students choose significantly more higher level mathematics courses than do their matched comparisons. Table 3 displays these results.

The results relative to the effects of SEED intervention are very consistent. In both a Center and non-Center environment, one semester of SEED instruction at the grades 4-6 level demonstrated immediate impact on mathematics achievement as measured by *ITBS* Total Mathematics, Math Concepts, Math Problem Solving, and Math Computation. Follow-up of students who had one semester of SEED instruction in a non-Center environment also demonstrated retention of mathematics skills two years after exposure to SEED and a tendency of former SEED students to enroll in a greater number of higher level mathematics courses.

When more than one semester of SEED instruction was examined, there was a contaminating factor relative to the results. That is, all students who had more than one semester of SEED were also enrolled in a Learning Center. There are some cooperative studies currently being implemented with the Detroit Public Schools that will enable us to examine the impact of more than one semester of SEED instruction in a non-Learning Center environment. Meanwhile, reading results of Center exposure were examined to attempt to provide information to better interpret Center mathematics results. The reading results were extremely inconsistent, with those instances where a reading effect was found washing out after only one year's removal from the Center environment. Given the consistency and longevity of the mathematics results, it was concluded that much of the impact on mathematics could be attributed to SEED instruction rather than to an overall Center effect.

Table 1
The Impact Of One, Two,
And Three Semester Of SEED/Center Instruction On Mathematics Achievement As Measured In Grade Equivalent Differences Over Matched Comparison Groups In Five Different Series Of Studies

Series	Grades(s)	Semesters In SEED	C	PS	C	T	Center Program	N
1	4	1 (82 or 83)	.39	.43	.65	.49	No	32
	5	1 (82 or 83)	.52	.16	.28	.32	No	87
	4	1 (83 or 84)	.38	.22	.14	.23	No	57
	5	1 (83 or 84)	.79	.33	.30	.48	No	66
	6	1 (83 or 84)	.09	-.21	.23	.04	No	72
2	4	1 (84 or 85)	.15	.21	.20	.19	Yes	517
	5	2 (85 or 86)	.50	.32	.41	.41	Yes	517
	6	3 (86 or 87)	.93	.59	.81	.78	Yes	517
3	4	1 (84 or 85)	.13	.10	.19	.14	Yes	479
	5	2 (85 or 86)	.61	.29	.45	.45	Yes	475
	6	3 (86 or 87)	.86	.44	.69	.61	Yes	475
	4	1 (85 or 86)	.34	.15	.41	.30	Yes	329
	5	2 (86 or 87)	.89	.41	.60	.63	Yes	329
	4	1 (86 or 87)	.52	.29	.52	.45	Yes	545
	6	3 (88 or 89)	1.04	.65	.82	.83	Yes	545
4	4	1 (86 or 87)	.65	.33	.68	.56	Yes	294
	6	3 (88 or 89)	.90	.48	.79	.72	Yes	294
	4	1 (85 or 86)	.40	.17	.47	.34	Yes	247
	5	2 (86 or 87)	.85	.47	.61	.64	Yes	247

Note: All underlined comparisons are statistically significant, $p \leq .05$.
Data are grouped into unique groups of students.

C = Concepts
PS = Problem Solving
C = Computation
T = Total Math

Table 1 (continued)
The Impact Of One, Two,
And Three Semester Of SEED/Center Instruction On Mathematics Achievement As Measured In Grade Equivalent Differences Over Matched Comparison Groups In Five Different Series Of Studies

Series	Grades(s)	Semesters In SEED	C	PS	C	T	Center Program	N
	4	1(84 or 85)	.15	.12	.22	.17	Yes	337
	5	2 (85 or 86)	.56	.30	.44	.43	Yes	337
	6	3 (86 or 87)	.96	.47	.76	.72	Yes	337
	4	1 (88 or 89)	.33	.22	.39	.32	Yes	424
	5	2(89 or 90)	.38	.17	.40	.32	Yes	424
	4	1 (89 or 90)	.25	.21	.28	.25	Yes	466
5	4	1S(88 or 89)	.55	.24	.41	.40	Yes	157
	5	2S(89 or 90)	.47	.27	.52	.43	Yes	157
	6	3S(90 or 91)	.95	.63.	.83	.79	Yes	157
	4	1W(88 or 89)	1.48	1.07	.92	1.15	Yes	67
	5	2W(89 or 90)	1.03	.54	.88	.82	Yes	67
	6	3W 90 or (91)	1.43	.75	1.03	1.07	Yes	67
	4	1S(89 or 90)	.31	.15	.47	.32	Yes	344
	5	2S (90 or 91)	.51	.29	.31	.38	Yes	344
	4	1W (89 or 90)	1.02	.65	.60	.76	Yes	166
	5	2W (90 or 91)	1.12	.69	.60	.81	Yes	166
	4	1S (90 or 91)	.41	.16	.14	.24	Yes	483
	4	1W (90 or 91)	.69	.23	.16	.36	Yes	286

Note: **All underlined comparisons are statistically significant, $p \leq .05$.**
Data are grouped into unique groups of students.

C = Concepts
PS = Problem Solving
C = Computation
T = Total Math

Table 2
Longitudinal Follow-up Of Achievement (ITBS) Of SEED/Center And Comparison Students[1] 1985-1991

SEED, 1985-87	Spring, 1985			Spring, 1986			Spring, 1987			Spring, 1989[2]			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	5.01**	4S	337	6.32**	5S	337	7.57**	6S	337	8.61**	8	337	-	10	150
Problem Solving	4.49*			5.47**			6.44**			7.82*			-		
Computation	5.17**			6.49**			7.63**			8.68**			-		
Math Total	4.89**			6.09**			7.21**			8.37**			10.58**		
Reading	4.43**			5.75**			6.24**			7.30			10.61		

COMPARISON	Spring, 1985			Spring, 1986			Spring, 1987			Spring, 1989			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	4.86	4	337	5.76	5	337	6.61	6	337	8.27	8	337	-	10	150
Problem Solving	4.37			5.17			5.97			7.60			-		
Computation	4.95			6.05			6.87			8.41			-		
Math Total	4.72			5.66			6.49			8.11			10.01		
Reading	4.25			5.53			5.92			7.33			10.08		

Where:

μ = **mean grade equivalent**
G = **grade tested**

*p≤.05
**p≤.01

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[1] SEED/Center students had three semesters of SEED in grades 4-6, 1984-87.
[2] DISD testing program does not include the ninth grade.

Table 3
Number and Percentage Of
Higher Level Mathematics
Courses Enrolled In
By Former SEED And Comparison Students[1]

COHORT[2]	SEED						COMPARISON					
	N	M	H	A	HM	P	N	M	H	A	HM	P
1989 (8)	278	1393	669	5.01	2.41**	48.1**	272	1341	477	4.93	1.75	35.5
1988 (9)	230	1605	569	6.98	2.47**	35.3**	215	1509	399	7.02	1.86	26.5
1987 (10)	301	2853	798	9.48	2.65	27.9	294	2768	783	9.41	2.66	28.3
1984 (G)	200	2114	1228	10.57	6.14**	58.1**	215	2132	906	9.92	4.21	42.5
1983 (G)	197	2143	1390	10.88	7.06**	64.9	208	1913	1248	9.2	6.0	65.2

Where:

- **N = the number of students in the cohort**
- **M = the total number of math courses taken**
- **H = the number of higher level math courses taken**
- **A = the average number of semesters of math taken per student**
- **HM = the average number of semesters of higher level math courses taken per student**
- **P = the percentage of higher level math courses taken**

****p≤.01**

[1] The 1983 and 1984 cohorts were exposed to one semester of SEED and were not enrolled in Learning Centers.

[2] The date represents the last year that students were enrolled in SEED. The number in parenthesis represents the grade that the students were in in 1990-91.

THE EVALUATION OF PROJECT SEED
1990-91

William J. Webster and Russell A. Chadbourn

PROGRAM DESCRIPTION

PROJECT SEED is a nationwide program in which professional mathematicians and scientists from major universities and research corporations teach abstract, conceptually oriented mathematics to full-sized classes of elementary school children on a daily basis as an extra-period supplement to their regular arithmetic program. The mathematics is presented through the use of a Socratic group discovery format in which children discover mathematical concepts by answering a sequence of questions posed by the SEED instructor. Project SEED believes that only persons who understand mathematics in depth possess the versatility to capitalize on the unconventional and often original insights that children are capable of making in an open-ended mathematical dialogue. The initial mathematical topics are chosen from high school and college algebra to reinforce and improve the students' critical thinking and computational skills and to help equip them for success in college-preparatory mathematics courses at the secondary level. Subsequent material establishes the mathematical foundation for a number of advanced areas of study and progresses into advanced topics in abstract algebra and other areas. Project SEED teaches entire regular elementary school classes rather than specially selected groups of students. Although SEED was originally begun as a program for the educationally disadvantaged (the acronym SEED stands for *Special Elementary Education for the Disadvantaged*), the project now is implemented with all levels of children across the nation. In its Dallas Independent School District (DISD) implementation, SEED was used with all levels of students and was not intended as a program for a specific group of students. The DISD implementation of SEED also continued SEED's nationwide practice of using intact classes in the schools in which it is implemented.

A Typical SEED Class

Project SEED is a supplementary program which is taught entirely by the SEED specialist assigned to a given class. The students in the class receive regular baseline instruction in mathematics from their DISD teacher. (This will either be a mathematics teacher in a departmentalized setting or the classroom teacher in a self-contained setting.) The students then receive a period of SEED instruction four days a week from the SEED specialist. The fifth period is an inservice period for the SEED specialist which will be discussed in more detail later. In this fifth period, the students work at the direction of the classroom teacher. This work may or may not be related to the material taught in Project SEED at the discretion of the teacher, but it usually is

not. The teacher is present while SEED is being taught but has no direct instructional role in the project.

Instruction in the SEED program will be considered in two parts, the instructional methodology of SEED and the mathematics content of the program. SEED used a group instructional methodology. The class is taught using a series of directed questions. The instructor asks questions of individuals in the class or of the class as a whole. New material is introduced at a slow pace and the majority of classroom time is usually spend in working on applications related to material previously encountered or in reviewing new and previous work. This stress upon application and review is intended to ensure that the students have a solid foundation in previously learned material before new material is introduced.

The SEED specialist uses a number of devices to manage the instruction in the classroom. The students are required to respond to most of the questions and discussions in the class. The responses are given using hand signals unless the students are asked directly to respond verbally. Signals are used to indicate agreement and disagreement with the topics of discussion and to respond to questions. The purpose of the signals is to give the instructor continual feedback about student perceptions of the material, to ensure group response which involves most (if not all) of the students in the dialogue on the material, and to maintain a degree of order in the classroom which could not be achieved using verbal responses. On the basis of the observations of SEED classes during the process evaluation, the signals seem to succeed in accomplishing these purposes.

To help ensure student involvement, each student is called upon several times each period to provide answers or comment. In the event a student is not participating in the discussions, the SEED instructor will use such devices as having the student call upon another student to provide an answer or calling upon the student to provide a number for a problem. Other devices used to keep student involvement at a high rate include having all students participate in group verbal responses to questions, having students write answers to questions on their papers and checking all or part of the papers immediately, or having all students show the answer to a question on their fingers. These methods and a number of others are all designed to keep student interest and involvement high, as well as to accomplish other instructional objectives.

To mitigate problems associated with locus of control in the classroom, the SEED instructor moves frequently in the classroom and avoids teaching and questioning from the same spot. This also helps keep students attentive since, at any moment, the instructor may be asking the next question from any part of the room. SEED classes have a higher proportion of visitors than usual, and the visitors and the teacher are utilized by the instructor. For example, the instructor might ask a visitor to call upon a student with his or her hand up to answer a question. In this fashion, the students become accustomed to visitors, who are not usually a source of interruption in the classroom.

The primary feature of the instructional system, however, is the set of questions asked by the SEED specialist. Almost all of the instruction is done through the use of questions. Rarely does the instructor directly tell the students anything. This is done, again, to help keep the student actively involved in the progress of the class and to avoid having the student as a passive recipient of the subject material. The instructor, in preparing for the class, thinks through the subject matter to be presented and assembles a list of sequenced questions which will be used as the basis of the questions asked of the students in class. These questions develop the content to be covered in a logical and detailed sequence which is then transferred to the classroom and form the heart of the SEED instructional process. In general, the SEED classes observed in the process evaluation visits exhibited thorough preparation on the part of the instructors as evidenced by the careful sequence of questions used in the instructional process.

SEED Mathematics Content

The mathematics content observed in the SEED classes consisted primarily of a thorough preparation in pre-algebra mathematics and beginning concepts of abstract algebra, with examples taken from the real number system. Some of the topics observed included properties of positive and negative numbers, properties of exponents, the additive law of exponents, definition and properties of logarithms, use of the distributive law of real numbers to prove properties of positive and negative numbers, the definition and properties of additive and multiplicative identities, the definition of additive and multiplicative inverses, the definition and properties of negative exponents, the definition and application of summation and product symbols, and an introduction to mathematical series.

As indicated by the former General Superintendent, the Dallas Independent School District (DISD) has an underlying goal in instituting the SEED program. This goal is to encourage more students to participate in the high school algebra sequence and the mathematics sequences following algebra. The hope is that participation in the SEED program will give more students the motivation to take the course sequence and will equip them with the necessary mathematical skills to succeed in these sequences. The sample of mathematical skills observed in the SEED classes was relevant to this goal. One of the objectives of this study is, within the limitations discussed in the Methods section, to determine if this phenomenon can be documented.

SEED as a Classroom Methodology

During the 1982-83 school year, a number of SEED classroom observations were conducted by the District's Research and Evaluation Department. The procedure was informal with no quantifiable criteria, but, rather, it was based on impressions of the SEED program

contrasted with other instructional systems. These impressions are relevant because they further describe the treatment as implemented in the District.

According to an earlier evaluation report (Mendro, REIS83-019, 1983), the first impression produced by SEED was that it contained a highly effective instructional system which could be implemented successfully by a wide variety of instructors. The organization of the classroom management techniques was such that the program generally showed good control of instruction in all the classes observed.

The second positive feature of the SEED program was the inservice system. Recall that the SEED instructor teaches four periods and has one inservice period per class each week. The purpose of this inservice period is to conduct discussions with the classroom teachers about the students and the progress of the SEED class, and to observe other SEED instructors and provide them with feedback on their implementation of the program. This system has two obvious advantages. First, during an inservice period, the instructor has a chance to reflect on the instructional components of the program and his or her implementation of them; the instructor has a chance to see and critique other instructors, which helps keep these skills sharp and allows for transmission of effective techniques through direct observation; and finally, the instructor has a chance to participate in discussions with other instructors, all of whom share common problems and interests. This first advantage of the inservice period generally provides the instructor with a chance to keep the instructional techniques fresh and alive and gives the project a formal mechanism for transmitting effective teaching techniques. The second advantage is that during the non-inservice days, the instructor is liable at any time to have other SEED instructors and trainees sit in on a class and provide a required critique of his or her teaching that day. This process of continual peer-evaluation is perceived as an extremely powerful method of ensuring high quality teaching throughout the program.

Thus, the conclusion drawn regarding the instructional quality of SEED was that the program had a very good classroom management system. The quality of instruction was consistently good across the program and it seemed to have an excellent internal procedure for building and maintaining that quality.

PREVIOUS EVALUATION STUDIES

Four series of studies on the impact of SEED were completed during the 1987-88 through 1989-90 school years. All studies focused on the immediate and longitudinal impact of SEED instruction on achievement in and attitudes toward mathematics.

Series 1. The first series of studies examined the impact of one semester of SEED instruction on mathematics achievement and attitude. Six different treatment groups with their

respective comparison groups were compared relative to post-SEED achievement trends and mathematics course enrollment. The design was set up so that each study was replicated within the design. Analyses were performed on two separate and distinct groups of fourth, fifth, and sixth graders, each being followed for a period of five years. Further replication studies were accomplished by examining the immediate impact of SEED instruction on student achievement in the year that SEED was offered, thus examining the impact of SEED on a group of students that did not exhibit the mortality of the five-year longitudinal groups.

In the case of this series of studies, SEED students were exposed to regular math plus SEED instruction, while comparison students were exposed only to regular math. Thus, part of the treatment was additional exposure to mathematics (45 minutes). Longitudinal group sizes ranged from 32 to 87. Short-term group sizes ranged from 245 to 295. Initial groups were chosen in 1982-83 and 1983-84.

The results of this first series of studies suggested strong and consistent immediate impact of SEED instruction on mathematics achievement as measured by the Concepts, Problem Solving, Computation, and Total sections of the *Iowa Tests of Basic Skills (ITBS)*. These improved scores were generally present at least one year after students had been exposed to SEED. The results also suggested greater impact of SEED on the achievement of lower socioeconomic students. In addition, former SEED students clearly took higher percentages of advanced courses than did their matched comparisons. (Webster and Chadbourn, 1988).

Series 2. The second series of studies examined the achievement trends of students who were enrolled in SEED three semesters: one in the fourth grade in 1984-85, one in the fifth grade in 1985-86, and one in the sixth grade in 1986-87.

Project SEED has been implemented in three special schools since the 1984-85 school year. Although the schools have many special programs and arrangements, they were primarily designed to raise student achievement levels in reading. Classes were self-contained and the homeroom teacher generally taught all subject areas except music and art. We must recognize from the outset that the instructional treatment in mathematics represents an extra 45-minutes of SEED instruction per day for four days a week. Comparison students had mathematics instruction by either self-contained teachers or mathematics specialists for 60-minutes per day. SEED students had instruction by self-contained teachers (non-mathematics specialists) plus the instruction by SEED instructors. These were the best comparisons that were available, since all students in the special schools had SEED.

As in the series of studies outlined as Study 1 of this investigation, comparison groups were selected from groups of students similar to those who received SEED instruction. The same selection criteria were used as were used in Study 1 of the investigation except, of course, the comparison groups matched the characteristics of the Study 2 SEED students.

Two major questions were examined. First, were the post-SEED instructional achievement trends of SEED students different from those of comparison students who were not exposed to SEED? This question was examined separately using the Math Concepts, Math Problem Solving, Math Computation, and Math Total scores on the *ITBS*.

Second, given that the schools studied were Learning Centers and had many special arrangements over other schools, the same type of longitudinal analysis was done on reading. The case for a treatment effect of Project SEED would be greatly enhanced if math trends among Center students were more positive than reading trends. The Reading subtest of the *ITBS* was used for this analysis. In addition, SEED data bases were established so that SEED student achievement as well as mathematics course selection versus that of comparison students could be analyzed over succeeding years.

The cohort samples for this part of the study required four years of test data. There were 517 SEED and 517 comparison students. The samples were one hundred percent Black and Hispanic, and seventy-nine percent on free and reduced lunch. Their pre-1984 achievement levels ranged from the first to the tenth decile.

The results of this series of studies suggested an immediate impact of SEED at the fourth grade level on mathematics achievement. This impact increased at grade 5 and further accelerated at grade 6. Thus, students who entered the fourth grade about even with their peers left the sixth grade about one-half year ahead of their peers in Problem Solving and almost one year ahead in Concepts. In addition, they were at or above grade level in Concepts, Computation, and Total Math scores.

Both the SEED and comparison samples had Spring, 1984, mean scores of 3.33 in Reading. During the succeeding three years of instruction, the SEED sample advanced to a mean score of 5.98 while the comparison sample advanced to a mean score of 5.55. Thus, the SEED sample gained 2.65 grade equivalent units in reading while the comparison sample gained 2.22 grade equivalents in reading. Compare this to a mean gain of 3.18 grade equivalent units in mathematics for the SEED students versus 2.36 grade equivalents for the comparison group. (Webster and Chadbourn, 1988).

Series 3. The third series of studies replicated the Series 2 studies plus added an additional outcome variable, a criterion-referenced test entitled the *Survey Tests of Essential Elements/Learner Standards (STEELS)*. This series of studies also examined retention rates, enrollment in higher level mathematics classes, withdrawal rates, and long-term impact of SEED. Four different samples were used. These samples included: students who had SEED instruction in the Learning Centers in grades 4-6 in 1985 through 1988; students who had SEED instruction in the Learning Centers in grades 4-6 in 1986 through 1989; follow-up of students who had one semester of SEED in 1982-83 or 1983-84 as well as Learning Center students who had three semesters of SEED in

1984-87.

This series of studies on SEED took an indepth look at the impact of SEED instruction on mathematics achievement as measured by the *ITBS* and *STEELS* and on student attitudes toward mathematics as measured by the enrollment of students in advanced math courses. Most of the students in the SEED group were also Learning Center students, thus introducing an intervening variable into the process of interpreting the results. Analyses of Learning Center Reading achievement were conducted to provide some measure of the impact of the Centers independent of SEED. Early non-Center SEED groups were also studied for this purpose.

Although the primary focus of this series of investigations was to examine the impact of Project SEED in the Learning Center environment, part of the study focused on non-Learning Center students who had only one semester of SEED in the fourth, fifth, or sixth grade. Although the achievement impact of this strategy appeared to wash out after two years, former SEED students still appeared to enroll in more higher level math classes, withdraw from the District less, and be retained fewer times than did their matched comparison groups.

The results of this series of studies suggested that SEED instruction in the Learning Centers contributed substantially to increased mathematics achievement as measured by the *ITBS* and *STEELS*, increased enrollment in higher level mathematics courses, lowered grade retention and District withdrawal rates, a cumulative impact on mathematics achievement, that is, longer exposure to SEED (up to three semesters) appeared to accelerate measured mathematics achievement growth, and, retention of mathematics gains for a least two years after exposure to SEED. (Webster and Chadbourn, 1989).

Series 4. The fourth series of studies replicated the Series 3 studies and followed-up students who had been included in the Series 1 and Series 2 studies to determine longitudinal impact on mathematics achievement and enrollment in higher level mathematics courses. Eight different samples were used to implement three different studies.

The first was a study of students who were exposed to one, two, or three semesters of SEED instruction in the Centers culminating in the Spring of 1990. These students were compared with their matched comparison groups on the *ITBS* Math Total, Concepts, Problem Solving, and Computation subtests, as well as the *STEELS* Mathematics test. All comparisons were significant, $p \leq .01$, in favor of the SEED groups.

The second study was a longitudinal follow-up of these students who had three semesters of SEED in the Centers in 1984-87,1985-88, or 1986-89. These students were compared with their matched comparison groups on the Math Total, Concepts, Problem Solving, and Computation subtests of the *ITBS*. The results of this study replicated the finding of a cumulative impact on mathematics achievement of increasing semesters of SEED (up to three), of continued mathematics achievement impact up to two years after SEED instruction was completed, and of

more SEED students enrolling in higher level mathematics courses.

The third study completed the follow-up of students who had had one semester of SEED in a non-Learning Center environment in 1982-83 or 1983-84. These students enrolled in more higher level mathematics courses than their matched comparisons. (Webster and Chadbourn, 1990).

Summary

In summary, this series of studies on SEED took an indepth look at the impact of SEED instruction on mathematics achievement as measured by the *ITBS* and *STEELS* and on student attitudes toward mathematics as measured by the enrollment of students in advanced math courses. Most of the students in the SEED group were also Learning Center students, thus introducing an intervening variable into the process of interpreting the results. Analyses of Learning Center Reading achievement was conducted to provide some measure of the impact of the Centers independent of SEED. Early non-Center SEED groups were also studied for this purpose.

Although the primary focus of this series of investigations was to examine the impact of Project SEED in the Learning Center environment, part of the study focused on non-Learning Center students who had only one semester of SEED in the fourth, fifth, or sixth grade. The achievement impact of only one semester of SEED instruction was present after two years and former SEED students enrolled in more higher level math classes than did their matched comparison groups.

The results of these studies in the Learning Centers suggested that SEED instruction in the Learning Centers contributed substantially to increased mathematics achievement as measured by the *ITBS* and *STEELS*, increased enrollment in higher level mathematics courses, a cumulative impact on mathematics achievement (longer exposure to SEED appeared to accelerate measured mathematics achievement growth), and retention of mathematics gains for at least two years after exposure to SEED.

STUDY DESCRIPTION

The Theoretical Comparison Group

In the field of practical evaluation it is often impossible to implement true experimental designs. The concept of randomly assigning students to treatments is repugnant to most educators, particularly in situations where it is perceived that one group of randomly assigned students will be deliberately withheld from what is often believed to be an effective educational treatment. Thus the problem of identifying appropriate comparison groups is crucial to the interpretability of results. The literature is replete with warnings of the threats to the validity of experiments involved

in comparing non-randomly assigned intact groups.

All of the comparisons in this series of studies utilize theoretical comparison groups. Each student in each of the experimental groups (SEED) was systematically matched to a comparison student. These comparison students were drawn from many District schools and thus represent many different math treatments. The one thing that they all have in common is that they have not been exposed to SEED. All matching was done in the year prior to exposure to SEED. Variables used in the matching process were:

1. sex
2. ethnicity
3. grade (previous and current year)
4. socioeconomic status as indicated by free lunch
5. achievement levels (Math Total)

Design

Major Evaluation Questions

The major purpose of this series of studies is to determine if the findings from the previous studies can be replicated and extended to the middle school level. Major evaluation questions include:

1.0 What is the impact of one, two, and three semesters of SEED instruction at the 4-6 level on mathematics achievement as measured by the *ITBS*?

2.0 Is there a cumulative impact of SEED instruction on mathematics achievement?

3.0 Do former SEED students enroll in more higher level math classes than their non-SEED comparison groups.

4.0 What is the long-term impact of three semesters of SEED instruction on mathematics achievement?

All SEED and comparison groups were matched on pretreatment variables. The variables were sex, ethnicity, socioeconomic status, grade level, and achievement level on the Mathematics Total subtest of the *ITBS*. Seven different samples were used:

1.0 Students who had one semester of SEED in the South Dallas Learning Centers in the fourth grade in 1990-91; two semesters of SEED in the South Dallas Learning Centers in the fourth and fifth grade in 1989-90 and 1990-91; or, three semesters of SEED in the South Dallas Learning Centers in the fourth, fifth, and sixth grades in 1988-89, 1989-90, and 1990-91. These students and their matched comparison groups were compared on achievement on the *ITBS* (Study A). Further cross-replication was accomplished by also using three samples of students from the West Dallas Learning Centers.

2.0 Students who had three semesters of SEED in the South Dallas Learning Centers in grades 4-6 in 1984-87, 1985-88, 1986-89, or 1987-90. These students and their matched comparison groups were compared on achievement on the *ITBS* both for the years that they were exposed to SEED and up to two years later. Course enrollment was also compared for these students (Study B).

Thus, two different series of studies were conducted.

Study A. Study of students who were exposed to one, two, or three semesters of SEED instruction in the Centers culminating in Spring, 1991. These students were compared with their matched comparison group on the *ITBS* Math Total, Concepts, Problem Solving, and Computation Subtests. Their *ITBS* Reading subtests were also compared as a point of reference for their math results. Both South and West Dallas samples were used.

Study B. Longitudinal follow-up of those students who had three semesters of SEED in the Centers in 1984-87, 1985-88,1986-89, or 1987-90. These students were compared with their matched comparison groups on the Math Total, Concepts, Problem Solving, and Computation subtests of the *ITBS*. Their *ITBS* Reading scores were also compared to those of their matched comparison group as a point of reference for their math results. Enrollment in higher level math courses was also compared.

Limitations

Project SEED is currently implemented in the Learning Centers. The Learning Centers are special grades 4-6 and 7-8 schools that have a number of enhancements over regular schools. It is practically impossible to eliminate completely the effects of the Learning Centers from the effects of SEED instruction. However, a number of observations seem appropriate.

The Learning Centers were established in 1984-85. For the first two years of operation, the Learning Centers had staff incentive pay goals based on student reading achievement. Mathematics achievement was not part of the goal, but was added for the 1986-87 school year. The reader will note that all comparisons in this study include longitudinal reading comparisons. It was reasoned that if there were major differences between reading achievement trends and mathematics achievement trends, and reading achievement was, and still is, the primary goal of the Learning Centers, that much of the mathematics achievement differences could be attributed to Project SEED.

In 1986-87 the Learning Centers implemented a Computer Math Program that was to supplement Project SEED. That is, Project SEED was to be taught one semester and Computer Math was to be taught one semester. According to the Program Manager, 1986-87 was beset with implementation problems for the Computer Math Program. Insufficient hardware, no software, and not enough computer specialists were among the problems that plagued the program during most of the 1986-87 school year. Thus, any impact that the Computer Math program had would have to be reserved for 1987-90 and later.

For the 1990-91 school year, another math program was implemented in the Learning Centers. This program, called "Professor B", was implemented in grades PK-8. An analysis was conducted on the program at grade 3 in the Learning Centers, since grade 3 did not receive SEED.

At this level comparison students outscored the treatment group. There was also no treatment effect in the Learning Centers at grades 7 and 8. A treatment effect was noted in non-Learning Center schools at grades 4, 5, and 6. Thus it is possible that the "Professor B" program contributed to the 1990-91 mathematics results. However, positive math results have been reported for SEED since 1983-84.

A final confounding variable relates to teacher training. During the summer of 1986, all Center math teachers were trained in SEED strategies by Project SEED staff. This training had, of course, varying influence on different teachers.

Method

Grade equivalent scores, the scale scores for the *ITBS*, were used for all achievement comparisons. Tests for statistical significance were computed on all comparisons using tests for the differences between means for correlated data. In all cases directional tests were used. Where there were initial group differences, a covariance adjustment was used.

Characteristics of the samples used in the various studies included a high percentage of Black students (over 80%), about 80% students that were on free or reduced lunch, and students who scored in every decile of the pretreatment achievement distributions.

RESULTS

Results are reported in relation to the major evaluation questions investigated.

1.0 What is the impact of one, two, and three semesters of SEED instruction at the 4-6 level on mathematics achievement as measured by the *ITBS*.?

Tables 1 through 6 display the impact of one, two, and three semesters, respectively, of SEED instruction in the South and West Dallas Centers on mathematics achievement as measured by the *ITBS* Concepts, Problem Solving, Computation, and Total Mathematics subtests. Since SEED is implemented in the Learning Centers, the impact of the Centers on Reading is also reported. This portion of the study is designed in such a manner that there is a replication study within a study since the South and West Dallas Centers are in different parts of the city and serve slightly different student economic levels. Tables 1, 3, and 5 report data for South Dallas while Table 2, 4, and 6 report similar data for West Dallas.

Study of Tables 1 through 6 suggest strikingly similar results. Tables 1 and 2 present the impact of one semester of SEED instruction in the Centers on mathematics achievement in South and West Dallas respectively. All comparisons are significant in favor of the SEED students after one semester of SEED instruction. Mathematics Concepts shows the greatest impact from SEED

Table 1
The Impact Of One Semester Of
SEED Instruction On Mathematics
Achievement, South Dallas Centers,
Spring, 1991

SEED, 1991	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	3.75	0.96	3	-	5.27	1.29	4	.41**	483
Problem Solving (*ITBS*)	3.33	1.00		-	4.41	1.25		.16**	
Computation (*ITBS*)	3.96	0.83		.03	4.97	0.97		.14**	
Total (*ITBS*)	3.68	0.82		-	4.88	1.05		.24**	
Reading (*ITBS*)	3.44	1.06		-	4.10	1.16		-	

COMPARISON, 1991	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	3.77	0.93	3	.02	4.86	1.34	4	-	483
Problem Solving (*ITBS*)	3.35	1.02		.02	4.25	1.32		-	
Computation (*ITBS*)	3.93	0.88		-	4.83	1.01		-	
Total (*ITBS*)	3.68	0.82		-	4.65	1.10		-	
Reading (*ITBS*)	3.54	1.10		.10	4.16	1.18		.06	

Where:

μ = mean grade equivalent

S = standard deviation

G = grade tested

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the group that is highest

*p≤.05
**p≤.01

Table 2
The Impact Of One Semester Of SEED Instruction On Mathematics Achievement, West Dallas Centers, Spring, 1991

SEED, 1990	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	3.85	0.97	3	.08	5.60	1.46	4	.69**	286
Problem Solving (*ITBS*)	3.31	0.97		-	4.66	1.39		.23**	
Computation (*ITBS*)	4.05	0.85		-	3.98	0.89		.16**	
Total (*ITBS*)	3.74	0.80		-	5.12	1.22		.36**	
Reading (*ITBS*)	3.25	0.98		-	3.91	1.12		-	

COMPARISON, 1990	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	3.77	0.92	3	-	4.91	1.24	4	-	286
Problem Solving (*ITBS*)	3.45	0.97		.14	4.44	1.26		-	
Computation (*ITBS*)	4.09	1.16		.04	4.94	0.96		-	
Total (*ITBS*)	3.74	0.80		-	4.76	0.36		-	
Reading (*ITBS*)	3.51	1.07		.26**	4.20	1.12		.29	

Where:

μ = mean grade equivalent

S = standard deviation

G = grade tested

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the group that is highest

*p≤.05

**p≤.01

Table 3
The Impact Of One And Two Semesters Of SEED Instruction On Mathematics Achievement, South Dallas Centers, Spring, 1990-91

SEED, 1990-91	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	4.90	1.18	4	.31**	6.65	1.34	5	.51**	344
Problem Solving (*ITBS*)	4.26	1.13		.15**	5.65	1.29		.29**	
Computation (*ITBS*)	5.28	1.03		.47**	6.27	1.20		.31**	
Total (*ITBS*)	4.82	0.99		.32**	6.19	1.15		.38**	
Reading (*ITBS*)	4.37	1.03		.09	5.24	1.21		.02	

COMPARISON, 1990-91	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	4.59	1.20	4	-	6.14	1.48	5	-	344
Problem Solving (*ITBS*)	4.11	1.26		-	5.36	1.36		-	
Computation (*ITBS*)	4.81	0.97		-	5.96	1.14		-	
Total (*ITBS*)	4.50	1.01		-	5.82	1.20		-	
Reading (*ITBS*)	4.28	1.14		-	5.22	1.30		-	

Where:

μ = mean grade equivalent

S = standard deviation

G = grade tested

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the group that is highest

*p≤.05
**p≤.01

Table 4
The Impact Of One And Two Semesters Of SEED Instruction On The Mathematics Achievement, West Dallas Centers, Spring, 1990-91

SEED, 1990-91	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	5.39	1.37	4	1.02**	7.02	1.63	5	1.12**	166
Problem Solving (*ITBS*)	4.46	1.23		.65**	5.78	1.44		.69**	
Computation (*ITBS*)	5.37	0.97		.60**	6.33	1.31		.60**	
Total (*ITBS*)	5.08	1.10		.76**	6.38	1.36		.81**	
Reading (*ITBS*)	4.64	1.13		.60**	5.28	1.29		.26**	

COMPARISON, 1990-91	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	4.37	1.13	4	-	5.90	1.31	5	-	166
Problem Solving (*ITBS*)	3.81	1.08		-	5.09	1.25		-	
Computation (*ITBS*)	4.77	0.95		-	5.73	1.05		-	
Total (*ITBS*)	4.32	0.91		-	5.57	1.07		-	
Reading (*ITBS*)	4.04	0.98		-	5.02	1.04		-	

Where:

μ = mean grade equivalent

S = standard deviation

G = grade tested

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the group that is highest

*p≤.05
**p≤.01

Table 5
The Impact Of Two And Three Semesters Of SEED Instruction On Mathematics Achievement, South Dallas Centers, Spring, 1989-91

SEED, 1991	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	6.56	1.53	5	.47**	7.74	1.56	6	.95**	157
Problem Solving (*ITBS*)	5.58	1.31		.27**	6.84	1.57		.63**	
Computation (*ITBS*)	6.42	1.09		.52**	7.64	1.27		.83**	
Total (*ITBS*)	6.19	1.17		.43**	7.40	1.37		.79**	
Reading (*ITBS*)	5.45	1.09		.24**	6.42	1.69		.36**	

COMPARISON, 1991	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	6.09	1.47	5	-	6.79	1.55	6	-	157
Problem Solving (*ITBS*)	5.31	1.42		-	6.21	1.58		-	
Computation (*ITBS*)	5.90	1.05		-	6.81	1.19		-	
Total (*ITBS*)	5.76	1.19		-	6.61	1.29		-	
Reading (*ITBS*)	5.21	1.22		-	6.06	1.36		-	

Where:

μ = mean grade equivalent

S = standard deviation

G = grade tested

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the group that is highest

*p≤.05
**p≤.01

Table 6
The Impact Of Two And Three Semesters Of SEED Instruction On Mathematics Achievement, West Dallas Centers, Spring, 1989-91

SEED, 1991	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	6.90	1.54	5	1.04**	8.26	1.47	6	1.42**	67
Problem Solving (*ITBS*)	5.94	1.07		.54**	7.14	1.26		.75**	
Computation (*ITBS*)	6.76	1.00		.88**	7.88	1.30		1.03**	
Total (*ITBS*)	6.53	1.08		.82**	7.76	1.24		1.07**	
Reading (*ITBS*)	5.32	1.11		.12	6.24	1.32		.28	

COMPARISON, 1991	Spring, 1990				Spring, 1991				
	μ	S	G	D	μ	S	G	D	N
Concepts (*ITBS*)	5.86	1.32	5	-	6.84	1.39	6	-	67
Problem Solving (*ITBS*)	5.40	1.10		-	6.39	1.36		-	
Computation (*ITBS*)	5.88	0.97		-	6.85	1.10		-	
Total (*ITBS*)	5.71	0.98		-	6.69	1.16		-	
Reading (*ITBS*)	5.20	1.12		-	5.96	1.22		-	

Where:

μ= mean grade equivalent

S = standard deviation

G = grade tested

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the group that is highest

*p≤.05
**p≤.01

instruction in both South and West Dallas. The reader should note the Center impact on Reading. In both South and West Dallas, the matched comparison groups outscored the Center groups in Reading, both starting and finishing higher. The differences were not statistically significant.

Tables 3 and 4 present the impact of one and two semesters of SEED instruction in the Centers on mathematics achievement in South and West Dallas, respectively. These are matched comparison groups. There were no differences between the SEED and comparison groups on mathematics or reading achievement at the end of the third grade, Spring 1989. The groups were, of course, also the same composition relative to sex, ethnicity, grade, and socioeconomic status. Yet, by the end of the fourth grade (one semester of SEED instruction), SEED students were significantly outperforming their matched comparisons on all mathematics measures in both South and West Dallas. By the end of the fifth grade, the mathematics achievement gap between SEED and comparison students had remained statistically significant on all measures and had widened over the previous year's gap on all mathematics tests except Computation. Meanwhile, reading performance showed no difference in the South Dallas Centers and a significant, but lessening with increasing exposure to the Center program, difference in West Dallas.

Tables 5 and 6 show the impact of two and three semesters of SEED instruction in the Centers on mathematics achievement in South and West Dallas, respectively. These groups were matched based on third grade, Spring, 1988 data. All differences after one semester of SEED instruction were significant on all mathematics comparisons ($p \leq .01$). Reading comparisons were not significant after one year of Center instruction. There was strong evidence of a cumulative impact of SEED instruction on mathematics performance after two and three semesters. Reading performance was enhanced by Center instruction in the South Dallas Centers but not the West Dallas Centers.

2.0 Is there a cumulative impact of SEED instruction on mathematics achievement?

Table 7 displays the impact of SEED instruction in mathematics on the various ITBS subtests and total after one, two, and three semesters of SEED instruction. The metric used is grade equivalent differences over matched comparison groups. The table summarizes every SEED study done in Dallas over the past eight years. It includes thirty-seven different grade comparisons and twenty-one separate SEED and comparison groups. Out of 148 different comparisons on four mathematics subtests of the ITBS, there is only one case where the students in the matched comparison group outscored the SEED students, and that case was not statistically significant. One hundred-forty of the one hundred-forty-eight comparisons were statistically significant in favor of SEED students.

Table 7
The Impact Of One, Two, And Three Semester Of SEED/Center Instruction On Mathematics Achievement As Measured In Grade Equivalent Differences Over Matched Comparison Groups In Five Different Series Of Studies

Series	Grades(s)	Semesters In SEED	C	PS	C	T	Center Program	N
1	4	1 (82 or 83)	.39	.43	.65	.49	No	32
	5	1 (82 or 83)	.52	.16	.28	.32	No	87
	4	1 (83 or 84)	.38	.22	.14	.23	No	57
	5	1 (83 or 84)	.79	.33	.30	.48	No	66
	6	1 (83 or 84)	.09	-.21	.23	.04	No	72
2	4	1 (84 or 85)	.15	.21	.20	.19	Yes	517
	5	2 (85 or 86)	.50	.32	.41	.41	Yes	517
	6	3 (86 or 87)	.93	.59	.81	.78	Yes	517
3	4	1 (84 or 85)	.13	.10	.19	.14	Yes	479
	5	2 (85 or 86)	.61	.29	.45	.45	Yes	475
	6	3 (86 or 87)	.86	.44	.69	.61	Yes	475
	4	1 (85 or 86)	.34	.15	.41	.30	Yes	329
	5	2 (86 or 87)	.89	.41	.60	.63	Yes	329
	4	1 (86 or 87)	.52	.29	.52	.45	Yes	545
	6	3 (88 or 89)	1.04	.65	.82	.83	Yes	545
4	4	1 (86 or 87)	.65	.33	.68	.56	Yes	294
	6	3 (88 or 89)	.90	.48	.79	.72	Yes	294
	4	1 (85 or 86)	.40	.17	.47	.34	Yes	247
	5	2 (86 or 87)	.85	.47	.61	.64	Yes	247

Note: All underlined comparisons are statistically significant, $p \leq .05$.
Data are grouped into unique groups of students.

C = Concepts
PS = Problem Solving
C = Computation
T = Total Math

Table 7 (continued)
The Impact Of One, Two,
And Three Semester Of SEED/Center Instruction On Mathematics Achievement As Measured In Grade Equivalent Differences Over Matched Comparison Groups In Five Different Series Of Studies

Series	Grades(s)	Semesters In SEED	C	PS	C	T	Center Program	N
	4	1(84 or 85)	.15	.12	.22	.17	Yes	337
	5	2 (85 or 86)	.56	.30	.44	.43	Yes	337
	6	3 (86 or 87)	.96	.47	.76	.72	Yes	337
	4	1 (88 or 89)	.33	.22	.39	.32	Yes	424
	5	2(89 or 90)	.38	.17	.40	.32	Yes	424
	4	1 (89 or 90)	.25	.21	.28	.25	Yes	466
5	4	1S(88 or 89)	.55	.24	.41	.40	Yes	157
	5	2S(89 or 90)	.47	.27	.52	.43	Yes	157
	6	3S(90 or 91)	.95	.63.	.83	.79	Yes	157
	4	1W(88 or 89)	1.48	1.07	.92	1.15	Yes	67
	5	2W(89 or 90)	1.03	.54	.88	.82	Yes	67
	6	3W 90 or (91)	1.43	.75	1.03	1.07	Yes	67
	4	1S(89 or 90)	.31	.15	.47	.32	Yes	344
	5	2S (90 or 91)	.51	.29	.31	.38	Yes	344
	4	1W (89 or 90)	1.02	.65	.60	.76	Yes	166
	5	2W (90 or 91)	1.12	.69	.60	.81	Yes	166
	4	1S (90 or 91)	.41	.16	.14	.24	Yes	483
	4	1W (90 or 91)	.69	.23	.16	.36	Yes	286

Note: **All underlined comparisons are statistically significant, $p \leq .05$.**
Data are grouped into unique groups of students.

C = Concepts
PS = Problem Solving
C = Computation
T = Total Math

Further study of the data in Table 7 shows that there are forty comparisons where differences after two semesters of SEED can be compared to differences after one semester of SEED and twenty comparisons where differences after three semesters of SEED can be compared to differences after two semesters of SEED. Because of gaps in the testing program, there are eight comparisons where the differences after one semester of SEED can be compared to differences after three semesters of SEED. Of the forty comparisons that examine the impact of two semester of SEED instruction versus one semester of SEED instruction, the differences between SEED and comparison groups are greater after two semesters of SEED instruction in thirty-one cases. Thus, in 77.5% of the cases students who had two semesters of SEED accelerated their academic advantage in mathematics, gained after exposure to one semester of SEED, over their comparisons. Four of the cases where this did not occur involved a group of West Dallas Center students who achieved phenomenal growth in the first year of SEED.

In comparing differences over the comparisons associated with three semesters of SEED versus two semesters of SEED, the differences between SEED and comparison groups were greater after three semesters of SEED in all twenty comparisons. Thus, in 100% of the cases students who had three semesters of SEED accelerated their academic advantage in mathematics, gained after exposure to two semesters of SEED, over their comparisons.

In similar comparisons done on the eight cases where data are available for one and three semesters of SEED, all eight comparisons show accelerated gains after three semesters of SEED. Sixteen of twenty comparisons utilizing the groups referred to in the previous paragraph favored three semesters of SEED over one semester of SEED with the four exceptions all coming from the one West Dallas group (1988-91).

Thus, evidence is strong that there is a cumulative impact of SEED instruction on mathematics achievement with two semesters further impacting student achievement over one semester and three impacting over two. This phenomenon occurred, in different configurations, in seventy-five of eighty-eight comparisons (85.2%) with eight of the contrary comparisons coming from the aforementioned one of the twenty-one groups of students.

Figures 1, 2, 3, and 4 display a composite of the thirty-two different grade comparisons tabled in Table 7. By collapsing gains across groups, a composite picture of comparative advantage of SEED students over comparisons can be displayed after one, two, and three semesters of SEED. The steeper the slope of the lines, the greater the impact of additional semesters of SEED instruction on mathematics achievement. The graphs clearly depict a cumulative impact of SEED instruction on Math Total (Figure 1), Math Concepts (Figure 2), Math Problem Solving (Figure 3), and Computation (Figure 4) as measured by the ITBS. The numbers

Figure 1. The Impact of One, Two, and Three Semesters of SEED Instruction on Math Total Scores as Measured in Grade Equivalent Differences Over Matched Comparison Groups

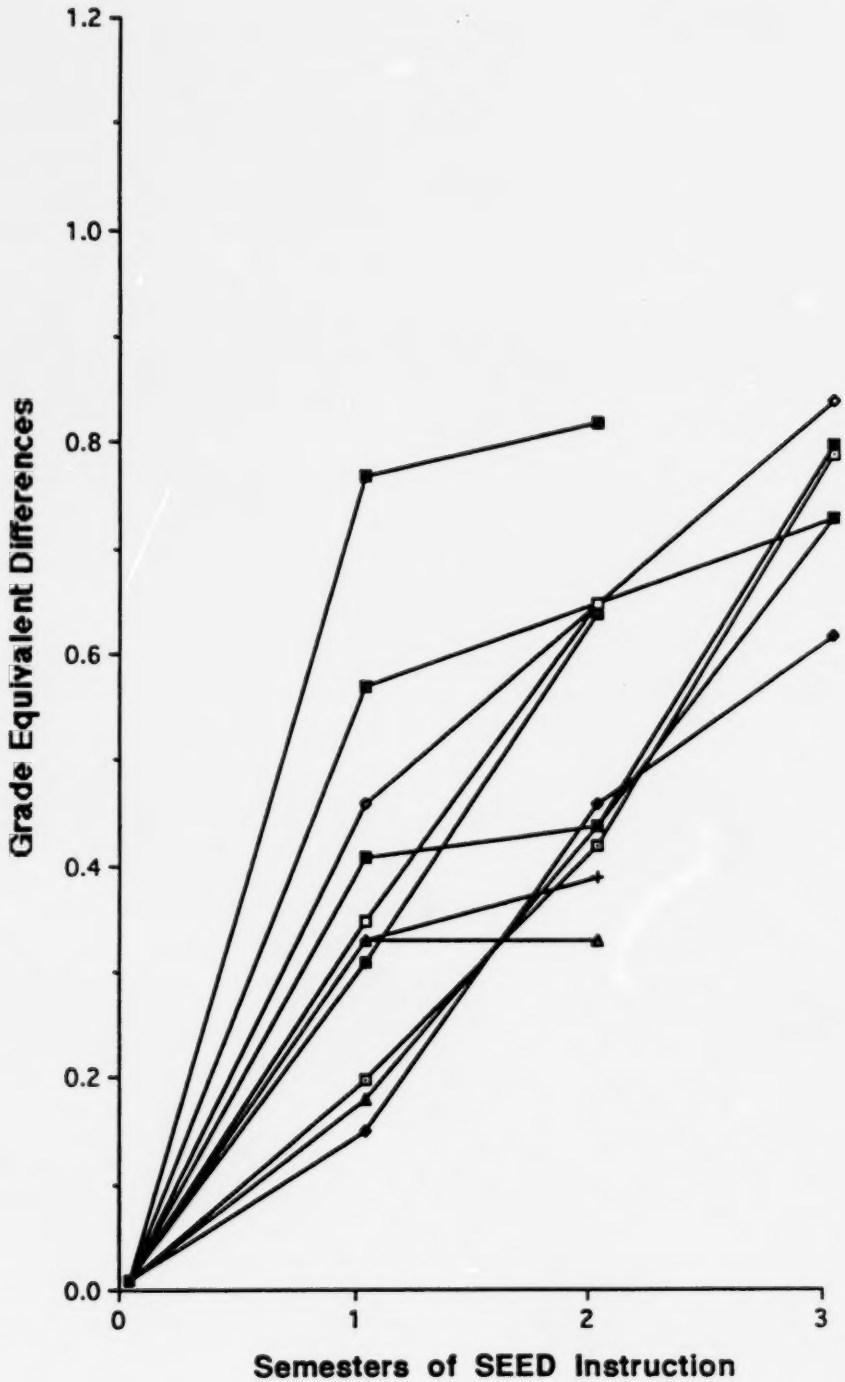


Figure 2. The Impact of One, Two, and Three Semesters of SEED Instruction on Math Concept Scores as Measured in Grade Equivalent Differences Over Matched Comparison Groups

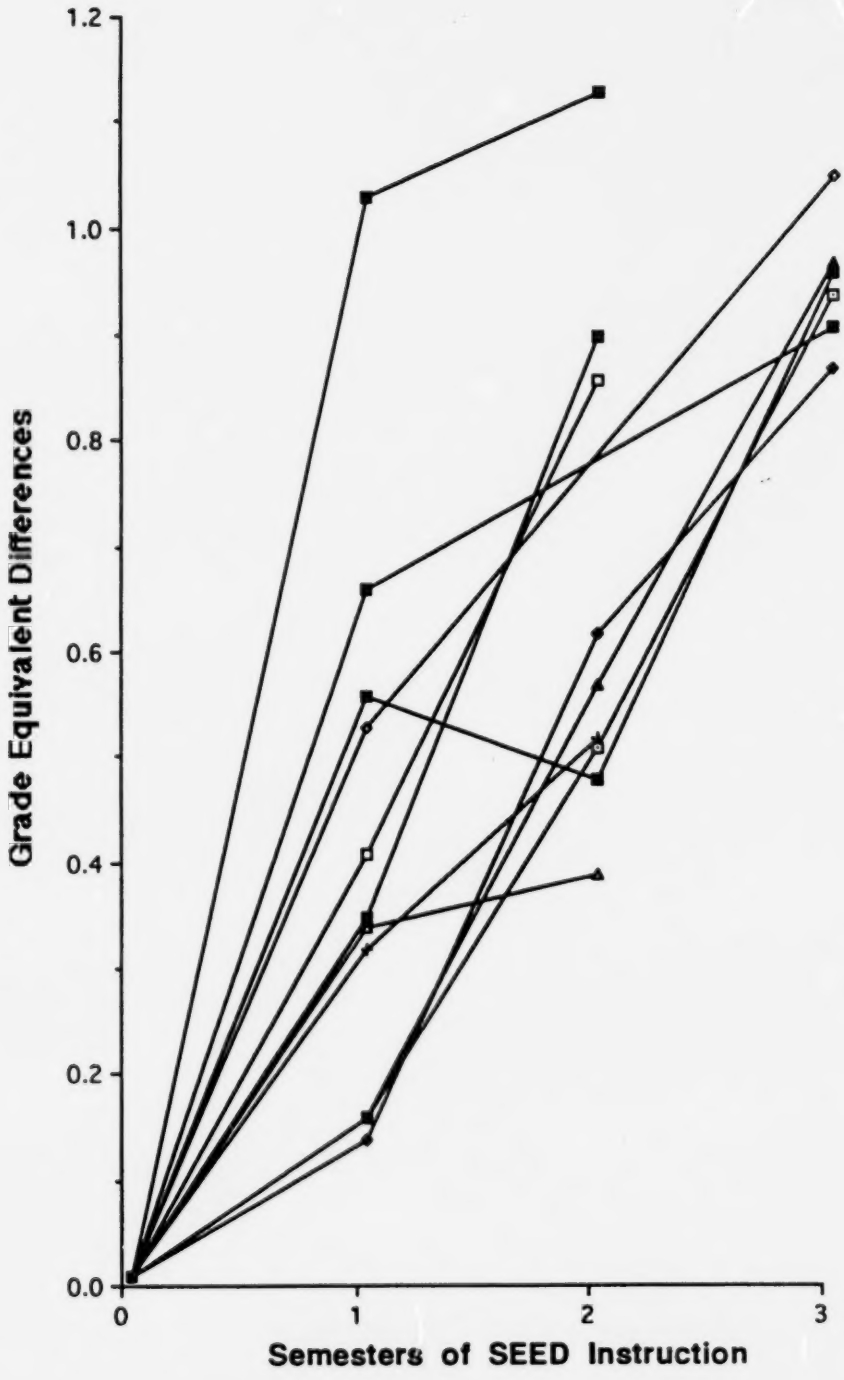


Figure 3. The Impact of One, Two, and Three Semesters of SEED Instruction on Math Problem-Solving Scores as Measured in Grade Equivalent Differences Over Matched Comparison Groups

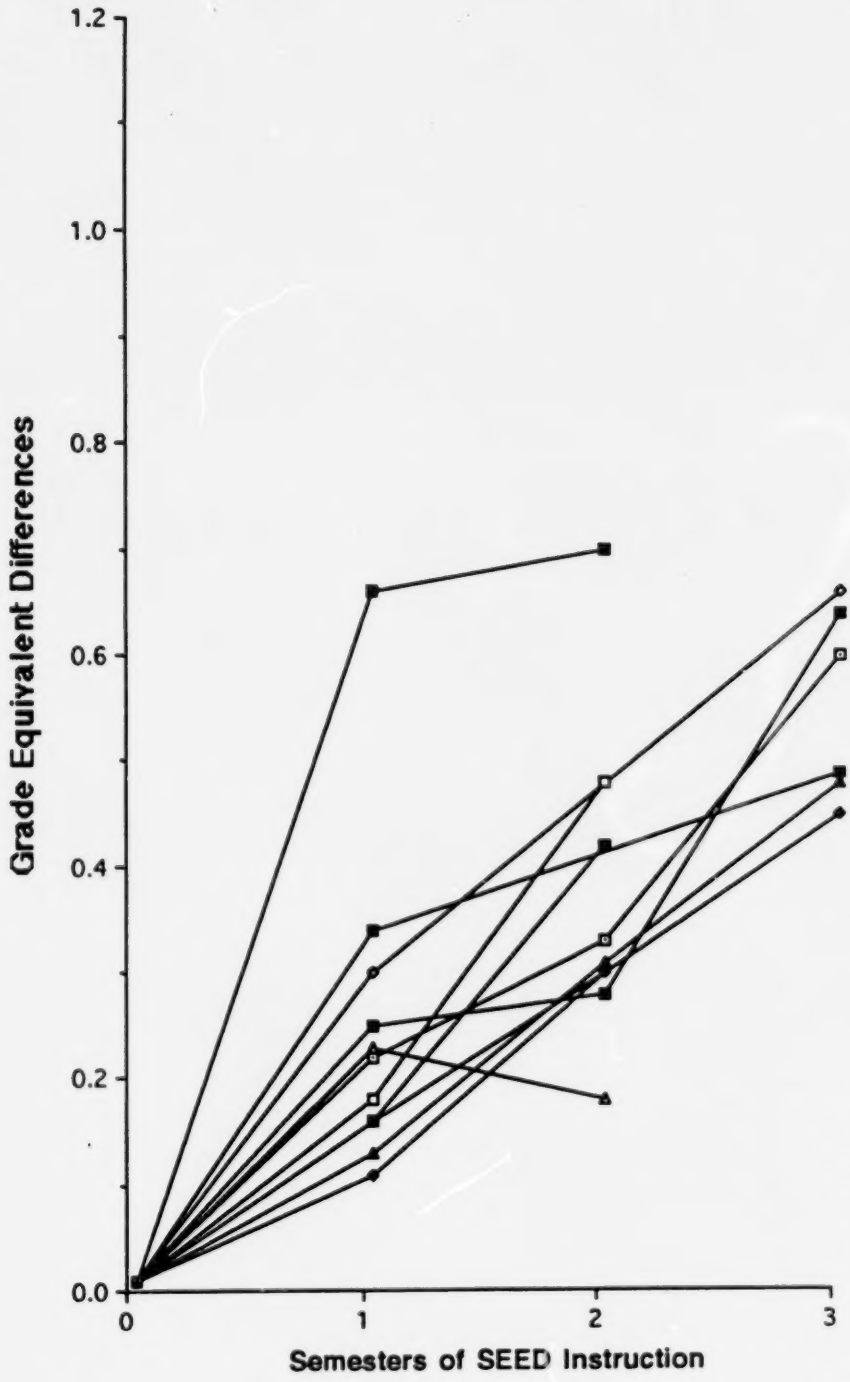
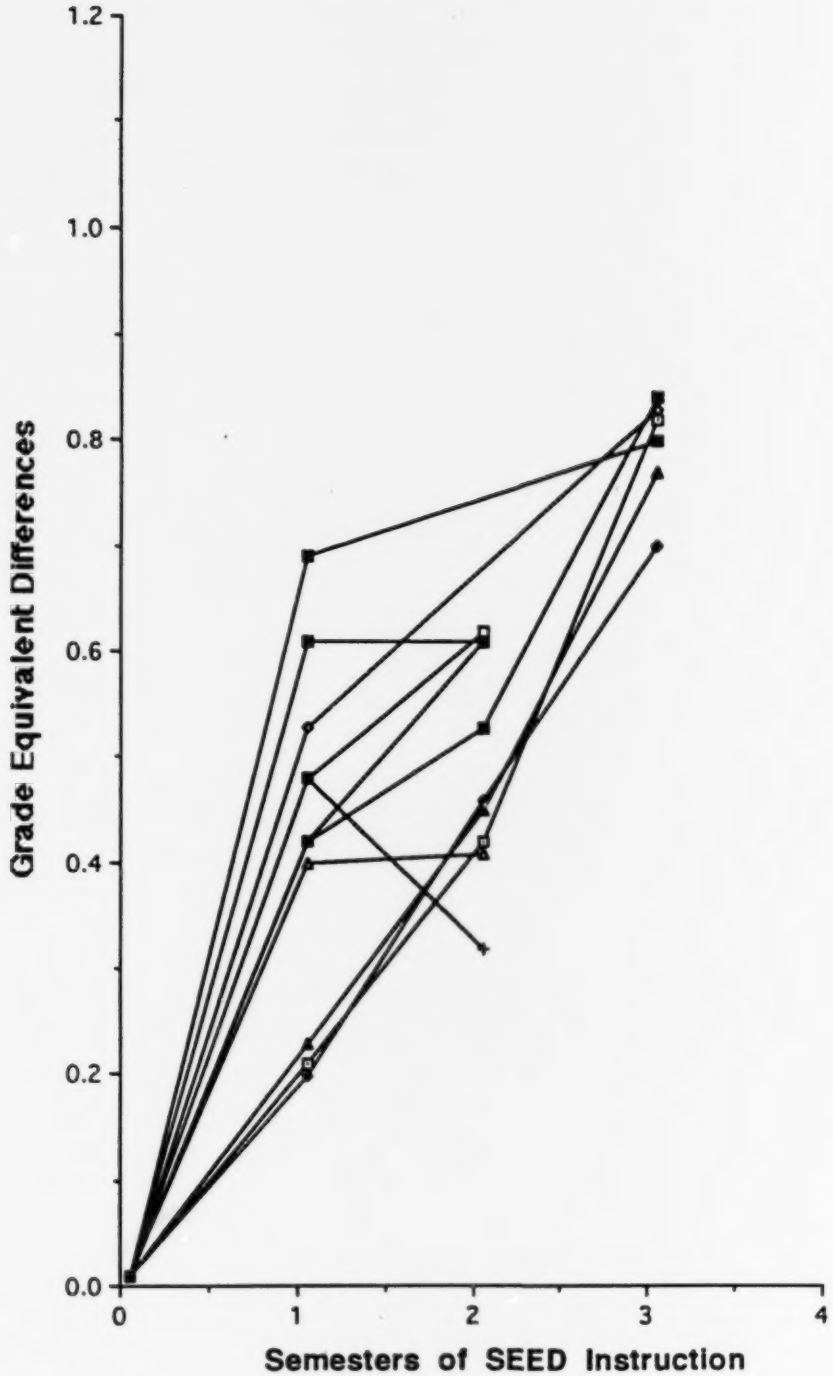


Figure 4. The Impact of One, Two, and Three Semesters of SEED Instruction on Math Computation Scores as Measured in Grade Equivalent Differences Over Matched Comparison Groups



graphed are once again grade equivalent differences over matched comparison groups.[1]

3.0 Do former SEED students enroll in more-higher level math classes than their non-SEED comparison groups?

This question was examined from two different perspectives. First, the percentage of higher-level math courses enrolled in by SEED and comparison students was analyzed. Second, the average number of higher-level math courses per student was examined.

Five different groups of former SEED students were studied. These groups include students who had SEED in the Learning Centers and matriculated from the sixth grade in 1989, 1988, or 1987. In 1990 these students were in either the eighth, ninth, or tenth grades. The other two groups include students who had one semester of SEED in 1982-83 or 1983-84. Those students were graduated in or before 1991. Table 8 displays relevant information about each of the five groups.

Analysis of Table 8 suggests that there is a difference between the number of higher-level math courses in which former SEED students enroll as compared to their matched comparison groups. In the 1989 and 1988 cohorts, former SEED students enrolled in significantly more higher-level mathematics courses and took a significantly higher proportion of those courses than did their matched comparison groups. There was no difference between the two groups in the 1987 cohort. However, in the 1984 and 1983 cohorts, former SEED students again enrolled in significantly more higher level mathematics classes and, in the 1984 cohort, took a significantly higher proportion of higher level math classes. In these two groups, which afforded the maximum length of comparison, former SEED students also appeared to take more semesters of mathematics than the matched comparison group. In the 1983 cohort this phenomenon accounted for the proportion of higher level courses taken not being significant since the SEED group, with fewer students, took 230 more semesters of mathematics than did the comparison group. This amounted to 1.68 more semesters of mathematics per student, 1.06 of which were higher level mathematics courses.[2]

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1 The West Dallas 1988-91 group was not included in the graphs due to the previously discussed anomalies.

2 Higher level math courses included for the 1989 cohort: Math 7 PH, Math 7 ADV, Math 8, and Algebra I PH, for the 1988 cohort: Math 7 PH, Math 7 ADV, Pre-Algebra PH, and Algebra I PH; for the 1987 cohort: Math 8 PH, Pre-Algebra PH, Algebra I PH, Algebra II PH, Algebra I, Geometry, Geometry PH, and Algebra II; and, for the 1984 and 1983 cohorts: Algebra I PH, Algebra II PH, Algebra I, Geometry, Geometry PH, Algebra II, Trigonometry H, Elementary Analysis H, Pre-Calculus H, Calculus W/AG AP, Number Theory H, Probability and Statistics H, and Math Topics.

Table 8
Number and Percentage Of
Higher Level Mathematics
Courses Enrolled In
By Former SEED And Comparison Students[1]

COHORT[2]	SEED						COMPARISON					
	N	M	H	A	HM	P	N	M	H	A	HM	P
1989 (8)	278	1393	669	5.01	2.41**	48.1**	272	1341	477	4.93	1.75	35.5
1988 (9)	230	1605	569	6.98	2.47**	35.3**	215	1509	399	7.02	1.86	26.5
1987 (10)	301	2853	798	9.48	2.65	27.9	294	2768	783	9.41	2.66	28.3
1984 (G)	200	2114	1228	10.57	6.14**	58.1**	215	2132	906	9.92	4.21	42.5
1983 (G)	197	2143	1390	10.88	7.06**	64.9	208	1913	1248	9.2	6.0	65.2

Where:

- **N** = the number of students in the cohort
- **M** = the total number of math courses taken
- **H** = the number of higher level math courses taken
- **A** = the average number of semesters of math taken per student
- **HM** = the average number of semesters of higher level math courses taken per student
- **P** = the percentage of higher level math courses taken

****p≤.01**

[1] The 1983 and 1984 cohorts were exposed to one semester of SEED and were not enrolled in Learning Centers.

[2] The date represents the last year that students were enrolled in SEED. The number in parenthesis represents the grade that the students were in in 1990-91.

4.0 What is the long-term impact of three semesters of SEED instruction on mathematics achievement?

Tables 9, 10, 11, and 12 show longitudinal trends of SEED and matched comparison groups on the various mathematics subtests of the ITBS. Table 9 follows students who had three semesters of SEED instruction in the South Dallas Learning Centers in the years 1985-87. Four years later, in the Spring of 1991, there are only 150 of the original 327 matched pairs remaining, but SEED students still have a significant advantage over their matched comparisons in mathematics (almost 6 months). The within group variance in reading is sufficiently large as to cause no significant difference in reading.

Table 10 follows former SEED 1986-88 students to the eighth grade in 1990. There are no test scores for these students in 1991 in the ninth grade since the District does not test at grade 9. Through the eighth grade, the former SEED students are well ahead of their matched comparisons in all math measures. There remains no difference between the two groups in reading.

Table 11 follows former SEED 1987-89 students to the eighth grade in 1991. Two-hundred-thirty-four matched pairs remain of the original 294. Three of the four mathematics tests remain significant two years after SEED instruction and the gap does not appear to be narrowing from the previous year (it remains at around four to five months over the matched comparison group). There remains no difference between the two groups in reading.

Table 12 follows former SEED 1988-90 students to the seventh grade in 1991. Once again, their mathematics performance remains superior to their matched comparison group on all mathematics subtests. Reading, which was different after three years of Center instruction, is no longer different one year later.

The data displayed in Tables 9-12 are very consistent. They show an immediate impact of SEED instruction on mathematics achievement after one semester, a cumulative impact of two and three semesters of SEED instruction on mathematics achievement, and retention of an academic advantage in mathematics for former SEED students up to four years after exposure to SEED. The reading results negate the hypothesis of a Center effect where, even after only one year's absence from the Centers, any impact of the Centers on reading has already washed out.[3] Figure 5 displays the immediate, cumulative, and longitudinal impact of SEED instruction on mathematics achievement.

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3 It is encouraging to note that with the two most recent groups, there was a Center impact on reading while the students were in the Center program. It, however, was no longer present one year after the Center experience.

Table 9
Longitudinal Follow-up Of Achievement
(ITBS) Of SEED/Center And
Comparison Students[1] 1985-1991

SEED, 1985-87	Spring, 1985			Spring, 1986			Spring, 1987			Spring, 1989[2]			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	5.01**	4S	337	6.32**	5S	337	7.57**	6S	337	8.61**	8	337	-	10	150
Problem Solving	4.49*			5.47**			6.44**			7.82*			-		
Computation	5.17**			6.49**			7.63**			8.68**			-		
Math Total	4.89**			6.09**			7.21**			8.37**			10.58**		
Reading	4.43**			5.75**			6.24**			7.30			10.61		

COMPARISON	Spring, 1985			Spring, 1986			Spring, 1987			Spring, 1989			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	4.86	4	337	5.76	5	337	6.61	6	337	8.27	8	337	-	10	150
Problem Solving	4.37			5.17			5.97			7.60			-		
Computation	4.95			6.05			6.87			8.41			-		
Math Total	4.72			5.66			6.49			8.11			10.01		
Reading	4.25			5.53			5.92			7.33			10.08		

Where:

μ = **mean grade equivalent**
G = **grade tested**

***p≤.05**
****p≤.01**

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[1] SEED/Center students had three semesters of SEED in grades 4-6, 1984-87.
[2] DISD testing program does not include the ninth grade.

Table 10
Longitudinal Follow-up Of Achievement (ITBS) Of SEED/Center And Comparison Students[1] 1986-1991

SEED, 1986-88	Spring, 1986			Spring, 1987			Spring, 1989			Spring, 1990		Spring, 1991[2]		
	μ	G	N	μ	G	N	μ	G	N	μ	G	μ	G	N
Concepts	4.97	4S		6.88**			7.99	7		8.68**	8	Not Tested	9	247
Problem Solving	4.30*			5.55**			7.48**			7.93**		Not Tested		
Computation	5.40**			6.62**			8.24**			8.69**		Not Tested		
Math Total	4.89**			6.35**			7.92**			8.43**		Not Tested		
Reading	4.74			5.17			6.58			7.66		Not Tested		

COMPARISON	Spring, 1985			Spring, 1987			Spring, 1989			Spring, 1990		Spring, 1991[2]		
	μ	G	N	μ	G	N	μ	G	N	μ	G	μ	G	N
Concepts	4.57	4		6.03	5		7.52	7		8.33	8	Not Tested	9	247
Problem Solving	4.13			5.08			7.18			7.57		Not Tested		
Computation	4.93			6.01			7.77			8.22		Not Tested		
Math Total	4.55			5.71			7.50			8.04		Not Tested		
Reading	4.63			5.00			6.57			7.72		Not Tested		

Where:

μ = **mean grade equivalent**

G = **grade tested**

[1] SEED/Center students had three semesters of SEED in grades 4-6, 1985-88.

[2] The ITBS/TAP are not administered at grade 9.

Table 11
Longitudinal Follow-up Of Achievement (ITBS) Of SEED/Center And Comparison Students[1] 1986-1991

SEED, 1987-89	Spring, 1986			Spring, 1987			Spring, 1989			Spring, 1990			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	4.08	3	294	5.47**	4S	294	7.77**	6S	294	8.16**	7	294	8.76**	8	234
Problem Solving	3.64			4.49**			6.83**			7.29			8.06		
Computation	4.03			5.49**			7.75**			8.12**			8.67**		
Total	3.92			5.16**			7.45**			7.85**			8.50**		
Reading	3.67			5.37**			6.55**			6.99			7.34		

COMPARISON	Spring, 1986			Spring, 1987			Spring, 1989			Spring, 1990			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	4.05	3	294	4.82	4	294	6.87	6	294	7.66	7	294	8.29	8	234
Problem Solving	3.67			4.16			6.35			7.10			7.84		
Computation	4.04			4.81			6.96			7.71			8.29		
Total	3.92			4.60			6.73			7.50			8.14		
Reading	3.71			5.18			6.18			6.86			7.52		

Where:

μ = mean grade equivalent
G = grade tested

*p≤.05
**p≤.01

[1] SEED/Center students had three semesters of SEED in grades 4-6, 1986-1989.

Table 12
Longitudinal Follow-up Of Achievement (ITBS) Of SEED/Center And Comparison Students, 1988-90

SEED, 1988-89	Spring, 1987			Spring, 1988			Spring, 1989			Spring, 1990			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	3.89	3	290	Not Tested	4S		6.86**	5S	290	7.52**	6S	290	7.84**	7	250
Problem Solving	3.33			Not Tested			5.59**			6.57**			7.35**		
Computation	3.89			Not Tested			6.54**			7.65**			7.89**		
Math Total	3.70			Not Tested			6.33**			7.24**			7.70**		
Reading	3.28			Not Tested			5.51**			6.11**			6.57		

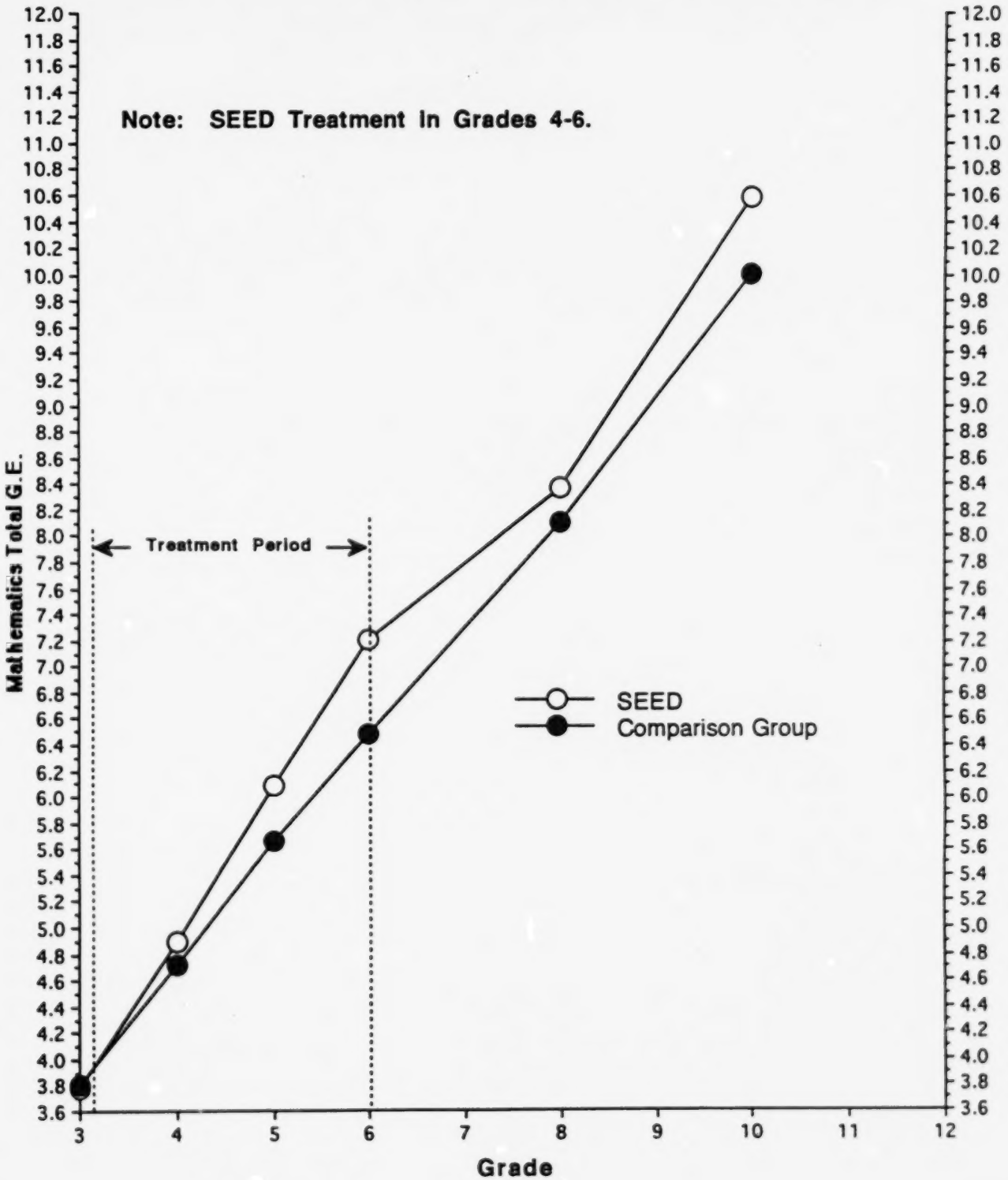
COMPARISON	Spring, 1987			Spring, 1988			Spring, 1989			Spring, 1990			Spring, 1991		
	μ	G	N	μ	G	N	μ	G	N	μ	G	N	μ	G	N
Concepts	3.93	3	290	Not Tested	4		6.12	5	290	6.64	6	290	7.15	7	250
Problem Solving	3.26			Not Tested			5.27			6.10			6.94		
Computation	3.92			Not Tested			6.01			6.75			7.40		
Math Total	3.70			Not Tested			5.80			6.50			7.17		
Reading	3.41			Not Tested			5.19			5.87			6.46		

Where:

μ = mean grade equivalent
G = grade tested

*p≤.05
**p≤.01

Figure 5. Longitudinal Follow-Up Study of the Achievement of SEED and Comparison Students, Grades 3 through 10



SUMMARY AND DISCUSSION

The results relative to the effects of SEED intervention are very consistent. In both a Center and non-Center environment, one semester of SEED instruction at the grades 4-6 level demonstrated immediate impact on mathematics achievement as measured by *ITBS* Total Mathematics, Math Concepts, Math Problem Solving, and Math Computation. Follow-up of students who had one semester of SEED instruction in a non-Center environment also demonstrated retention of mathematics skills two years after exposure to SEED and a tendency of former SEED students to enroll in a greater number of higher level mathematics courses.

When more than one semester of SEED instruction was examined, there was a contaminating factor relative to the results. That is, all students who had more than one semester of SEED were also enrolled in a Learning Center. There are some cooperative studies currently being implemented with the Detroit Public Schools that will enable us to examine the impact of more than one semester of SEED instruction in a non-Learning Center environment. Meanwhile, reading results of Center exposure were examined to attempt to provide information to better interpret Center mathematics results. The reading results were extremely inconsistent, with those instances where a reading effect was found washing out after only one year's removal from the Center environment. Given the consistency and longevity of the mathematics results, it was concluded that much of the impact on mathematics could be attributed to SEED instruction rather than to an overall Center effect.

In summarizing the impact of one or more semesters of SEED instruction at the grades 4-6 level, there are four generalizations that are immediately apparent. These are:

1. There is an immediate impact of one semester of SEED instruction on mathematics achievement as measured by the *ITBS.*

2. There is a cumulative impact of more than one semester of SEED instruction on mathematics achievement as measured by the *ITBS*. That is, the more semesters of SEED instruction that children are exposed to (up to three), the greater the difference in mathematics achievement between SEED students and their matched comparisons.

3. Retention of mathematics skills by former SEED students is still present four years after SEED instruction. That is, four years after completing their last of three semesters of SEED (one semester each in the fourth, fifth, and sixth grades), former SEED students now in the tenth grade still significantly outperform their matched comparisons in mathematics as measured by the *Tests of Achievement and Proficiency (TAP).*

4. Former SEED students enroll in significantly more higher level mathematics courses than do their matched comparisons. That is, in middle and high school, former SEED students choose significantly more higher level mathematics courses than do their matched comparisons.

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